WHITE PAPER

USDA Forest Service   Rocky Mountain Region   Pike & San Isabel National Forests

Plant Communities of the Pike and San Isabel National Forests in South-Central Colorado

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Author's Revision Note: this material was originally prepared as chapter II in *Plants of the Pike and San Isabel National Forest* (Powell 1982), a field guide produced for a forest inventory course offered by Trinidad State Junior College. Since limited copies of the field guide were printed, they are now unavailable except possibly at a few regional libraries.

An original copy of chapter II was scanned and processed with optical character recognition software, a process creating editable text. Making the scanned material available online, as a revised version, allowed me to make editorial changes to the text, and to add color photographs illustrating plant communities (all photographs in this white paper were acquired by David C. Powell).

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INTRODUCTION

A distant summer view of the southern Rocky Mountains shows a dark band of coniferous forest occurring above a lighter-colored grassland zone. Each of these contrasting areas seems to be homogeneous, and the border between them appears sharp. A closer view reveals great diversity within each zone and borders that are poorly defined: herbaceous communities and stands of deciduous aspen trees are scattered throughout the coniferous forest, and the species of dominant conifer changes from one site to another (Marr 1967).

At the foot of the mountains, fingers of forest and stands of tall deciduous shrubs invade the grassland zone for varying distances before becoming progressively less common and eventually disappearing altogether (Marr 1967).

This vegetation pattern demonstrates that the Rocky Mountains are actually broken up into a myriad of small units, many of which repeat in an intricate, changing pattern (Marr 1967). Making sense of this landscape mosaic is possible by using a concept called potential vegetation.

Concepts and Terminology

Potential vegetation is defined as the community of plants that would become established if all successional sequences were completed, without interference by humans, under existing environmental conditions. Potential vegetation, the theoretical endpoint of plant succession in the absence of disturbance, is used to classify and characterize the potential natural plant communities that would become established under existing climatic conditions (Daubenmire 1968).

A group of plant species that frequently occurs together is called a *plant community*. A climax (potential natural) plant community, which perpetuates itself in the absence of disturbance, is called a *plant association*. The plant association is the fundamental unit of potential vegetation classification. A plant association is named for the dominant overstory and undergrowth[2] plants, such as the subalpine fir/grouse whortleberry plant association.

Plant association is a specific type of plant community represented by stands occurring in places where environments are so closely similar that there is a high degree of floristic uniformity in all vegetation layers (Daubenmire 1968). Not only is vegetation uniformity important for plant association identification, but many abiotic components (landform, soils, etc.) should also be consistent across the stands representing any individual association (Johnston 1987).

Plant associations with the same overstory dominants comprise a *series*, such as the subalpine fir series. The land area capable of supporting a plant association is a *habitat type*. Even though plant associations refer to climax plant communities and habitat types refer to the land areas they could potentially occupy, both are used as equivalent terms in this document.

Note that plant association and habitat type are the two most common terms relating to potential vegetation because almost every classification of potential natural plant communities for the western United States has used one or the other of these terms (Alexander 1985).

Confusion often exists about the distinction between existing vegetation and potential vegetation. *Existing vegetation* differs from potential vegetation because it represents conditions as they exist today – what a land manager finds on the ground and deals with on a daily basis.

Historically, natural resource management was based on classifications of existing vegetation (e.g., Eyre 1980). Although maps displaying existing vegetation provide valuable information about current composition and structure, they supply little insight about site productivity and other management implications (Daubenmire 1973, Deitschmann 1973, Westveld 1951).

This means that the two classification approaches – potential vegetation and existing vegetation – tend to be used in different ways and for different purposes: existing vegetation is well suited for meeting operational needs because it represents 'what is' (current conditions), whereas potential vegetation is ideally suited for planning and assessment processes because it represents 'what could be' (ecological site potential) (Westveld 1951).

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[2] In this document, the terms undergrowth and understory are both used. *Undergrowth* refers to herbaceous and shrubby plants growing beneath a forest canopy; undergrowth does not include small trees such as seedlings or saplings. *Understory* refers only to small trees; in a forest comprised of multiple canopy layers, taller trees form the overstory and shorter trees the understory.

This document describes some representative plant communities for each vegetation zone occurring on the Pike and San Isabel National Forests, and it discusses ways in which they have adapted to their environment.[3]

Most of the plant community discussion occurs in the context of potential vegetation (e.g., plant associations), but existing vegetation is also mentioned by referring to successional (seral) stages of the potential vegetation type.

A diagram of the vegetation zones and their dominant physiognomic types is presented as figure 1.

Plant associations are seldom, if ever, 'born' in a climax condition. Climax stands result from a continuous progression of community types occurring in a successional sequence (the series of stages is called a sere); each stage in the successional sequence is called a seral stage (early-seral, mid-seral, late-seral, etc.).

Figure 2 illustrates a common successional sequence involving four seral stages of a montane-zone plant association for the Pike and San Isabel National Forests.

Since the mountain ranges of the Pike and San Isabel National Forests are often mentioned when describing plant communities and vegetation zones, their general location is presented in figure 3.

[3] For additional information about the vegetation of south-central Colorado, see Dix (1974), Marr (1967), and Peet (1978, 1981).

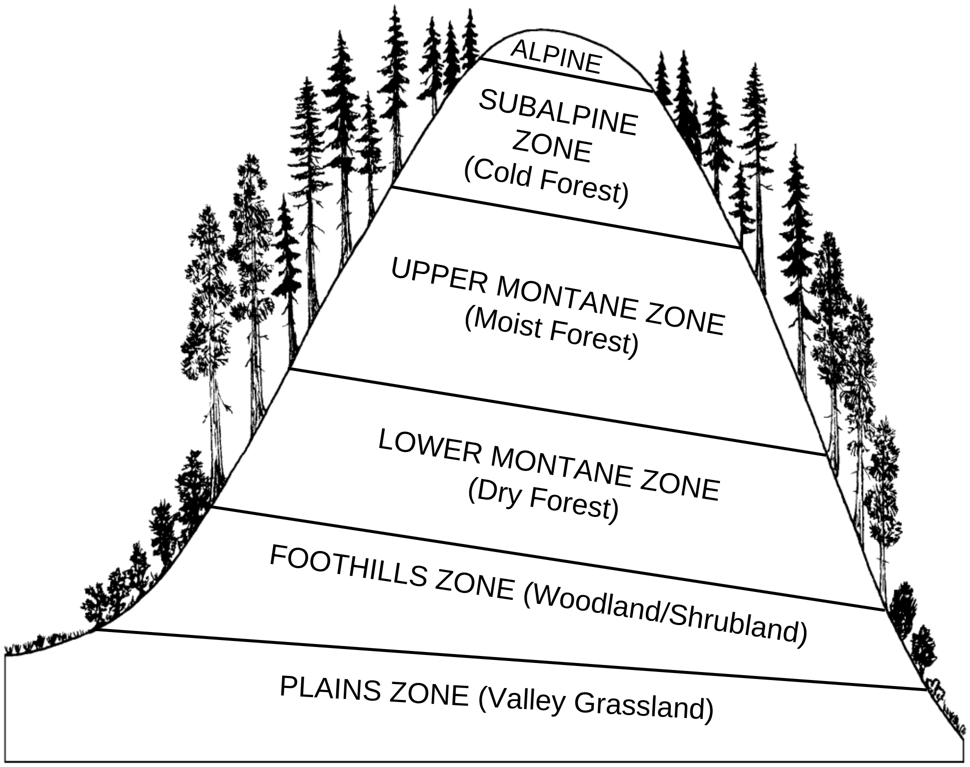

Figure 1–Vegetation zones of the southern Rocky Mountains in south-central Colorado. In the northern hemisphere, a south-facing slope receives more solar radiation than a flat surface, and a north-facing slope receives less (above, the south slope is to the left and the north slope is to the right). These solar radiation patterns result in the vegetation zones or bands shown in this figure – they are arranged vertically in response to elevation (moisture), and sloping downward from south to north (left to right) in response to slope direction or aspect (temperature). Three forested zones are summarized here:

Foothills. This zone generally occurs between 6,000 and 7,500 feet elevation, depending on slope exposure. It contains scrub oak, mountain mahogany, or pinyon-juniper woodlands at low elevations; ponderosa pine forest at moderate to high elevations; Douglas-fir forest on steep, cool, shaded slopes; and riparian, broadleaved forests of cottonwood and boxelder along large streams and rivers.

Montane. This zone generally occurs between 7,500 and 9,000 feet elevation, depending on slope exposure. Ponderosa pine forests, often with intermingled meadows of Arizona fescue and other bunchgrasses, dominate the lower montane zone. Douglas-fir forests occupy high-elevation sites and cool slope positions (north and east aspects). At the upper edge of this zone, lodgepole pine, quaking aspen, or spruce-fir forests are occasionally found. Groves of narrowleaf cottonwood occur along low-elevation waterways; with increasing altitude, they are gradually replaced by blue spruce forest.

Subalpine. This zone generally occurs between 9,000 and 11,500 feet elevation, depending on slope exposure. Douglas-fir, lodgepole pine, or quaking aspen forests dominate the lower subalpine zone, while spruce-fir stands occur at high altitudes and on cool, shaded exposures. This zone contains some of our most productive forest sites.

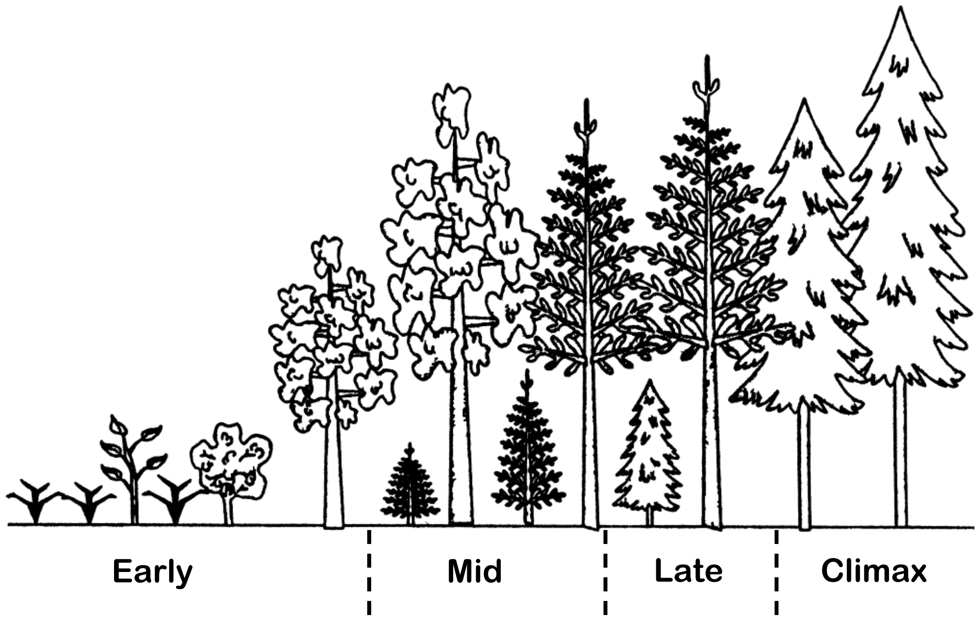

Figure 2–Seral stages for a montane-zone plant association of the Pike and San Isabel National Forests. The series of stages shown in this diagram is called a sere. After a stand-initiating disturbance event such as crown fire or regeneration cutting, a new plant community gets established and it gradually transitions through a series of stages, progressing from a simpler, somewhat disorganized state (early-seral stage) to a relatively complex, highly organized state (the climax plant community). The early-seral stage is initially dominated by grasses, forbs, and shrubs (some ecologists refer to this non-tree phase as a very-early stage), but shade-intolerant tree species also get established in early-seral communities. The mid-seral stage has a mix of species, with early-seral species (ponderosa pine above) and mid-seral species (Douglas-fir above) present in almost equal amounts. Late-seral stands have both mid-seral and late-seral tree species present (white fir is the late-seral species above). Although truly climax stands are relatively uncommon in our disturbance-influenced ecosystems, they feature a species composition where early- or mid-seral tree species are scarce or absent, and composition is dominated almost entirely by the late-seral species.

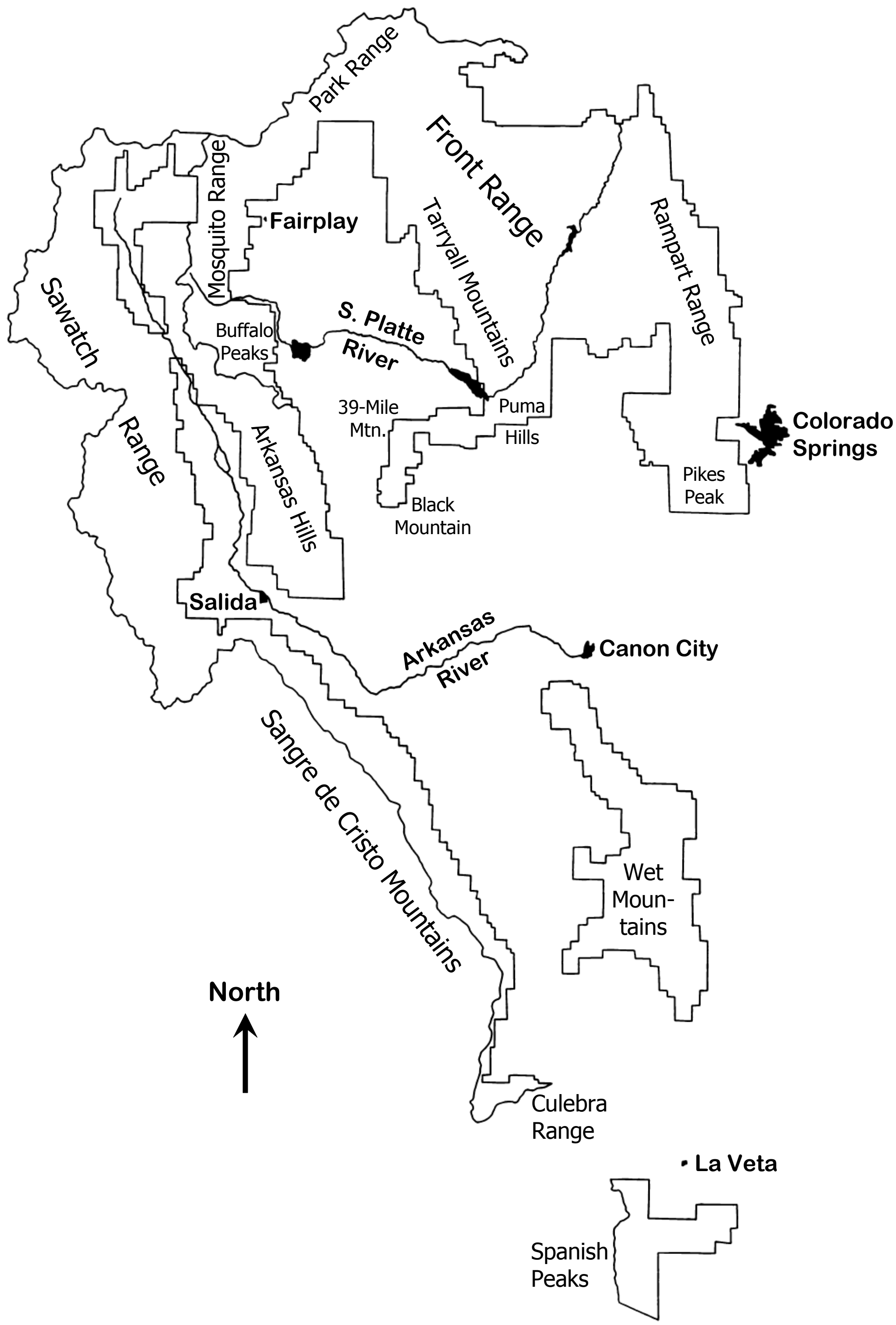

Figure 3–Generalized location of mountain ranges in the Pike and San Isabel National Forests of south-central Colorado; many of these ranges are mentioned in the text. Selected cities and river segments are included on the map for orientation purposes.

FOOTHILLS VEGETATION ZONE

The foothills vegetation zone generally occurs between 6,000 and 7,500 feet elevation, depending on slope exposure. This zone contains scrub (Gambel) oak, mountain-mahogany, or pinyon-juniper woodlands at low elevations; ponderosa pine forest at moderate to high elevations; Douglas-fir forest on steep, cool, shaded slopes on northerly exposures; and riparian, broadleaved forests of cottonwood and boxelder along large streams or rivers. Figures 4-6 describe and illustrate plant communities and vegetation conditions of the foothills zone.

Pinyon-juniper Woodlands

Oneseed juniper[4] has more ecological amplitude than pinyon pine, and it is normally the first tree species encountered above the plains vegetation zone. With increasing elevation, pinyon pine gets established and the typical pinyon-juniper woodland has taken shape.

Even though we always seem to map them in combination as a pinyon-juniper cover type, their differing ecological amplitude justifies having discrete climax series for pinyon pine and oneseed juniper – see the separate sections for the *Juniperus monosperma* and *Pinus edulis* series in *The Plant Associations of Region Two* (USDA Forest Service 1981).

Pinyon-juniper woodlands, which occur on every Ranger District of the Pike and San Isabel National Forests except possibly the South Platte, are especially common in the Arkansas Hills, Wet Mountains, and Spanish Peaks mountain ranges.

Pinyon-juniper woodlands have an interesting latitudinal distribution because the Pike and San Isabel National Forests represent their northernmost occurrence on the Front Range, notwithstanding small stands in Owl Creek Canyon (northwest of Fort Collins) and several canyons near Boulder, which are believed to be anomalies or outliers.

Pinyon pine and oneseed juniper communities usually have an undergrowth featuring grasses and shrubs adapted to xeric sites – good examples are the oneseed juniper/sideoats grama, oneseed juniper/blue grama, and pinyon pine/blue grama plant associations in *The Plant Associations of Region Two* (USDA Forest Service 1981).

In some areas of the western United States, pinyon-juniper woodlands have expanded when overgrazing allowed them to invade climax grasslands. Barring permanent degradation of the fine-textured soils as a result of grazing impacts, the pinyon-juniper plant community then functions as a successional stage, and

[4] Scientific plant names are provided in appendix 1.

it will eventually give way to the native grasslands after the perturbation (overgrazing) has been removed.

Special Habitats of the Foothills Vegetation Zone

Occasionally, shrubland plant associations occur in the upper foothills on sites with edaphic or topoedaphic restrictions (the Gambel oak/true mountain-mahogany plant association, for example). In fact, oak woodlands replace the pinyon-juniper woodlands and function as a transition type between grassland and ponderosa pine forest from the Palmer Lake Divide (located on the boundary between the South Platte and Arkansas River basins) to an area north of Denver.

The Palmer Lake Divide exerts a surprisingly strong influence on climatic patterns (especially precipitation) and plant community distribution for the southern Front Range (note that Interstate 25 crosses the Palmer Lake Divide at Monument Hill).

Gambel oak often forms clumps in areas with gentle or flat terrain, usually in response to edaphic variability. On steeper slopes, it tends to form dense, continuous thickets that may impede the establishment of conifers and other associated vegetation.

Gambel oak is similar to the pinyon-juniper type in that it also occurs at its northernmost Front Range latitude on the Pike and San Isabel National Forests. North of Denver, true mountain-mahogany is the dominant tall shrub of the foothills zone; south of Denver, Gambel oak is predominant.

Common shrub associates of Gambel oak include true mountain-mahogany, skunkbush sumac, common chokecherry, Saskatoon serviceberry, and antelope bitterbrush. South of Pueblo, many portions of the pinyon-juniper or oak woodlands have a desert-like appearance when cholla (cane cactus) is plentiful in the undergrowth.

Foothills drainages have one or more of the following trees as common overstory dominants – plains cottonwood, narrowleaf cottonwood, Rio Grande cottonwood, peachleaf willow, and boxelder. Lanceleaf cottonwood, a hybrid of narrowleaf and Rio Grande cottonwoods, also occurs in some portions of the foothills zone.

Figure 4–Vegetation transition between the plains and foothills zones, showing valley grassland on level terrain (foreground) merging with foothills communities of Gambel oak and pinyon-juniper, and with ponderosa pine forest on moist aspects (background). As mentioned in the text, Gambel oak tends to occur as a transitional foothills type in the area north of the Palmer Lake Divide (this divide is located on the boundary between the South Platte River and Arkansas River basins; Interstate highway 25 crosses the Palmer Lake Divide at Monument Hill). South of the Palmer Lake Divide, pinyon-juniper woodlands are more common as a transitional foothills type between plains-zone grasslands and the ponderosa pine forests of lower-montane environments.

Figure 5–Two edges of the foothills zone. At the lower edge of the foothills zone, low-stature communities of Gambel oak, smooth sumac, or another dominant shrub species will often be found intermingled with pinyon-juniper woodlands. At these low elevations, it may be a misnomer to use the term "pinyon-juniper woodland" because pinyon pine is often absent altogether; note how oneseed juniper occurs as round, low clumps on these dry sites (above). The opposite situation is often found at the upper edge of the foothills vegetation zone (below), where pure pinyon pine can occur instead of the mixed stands of pinyon pine and oneseed juniper typically encountered at lower elevations.

Figure 6–Two plant species of the foothills zone: cholla, a cactus species often found near the lower edge of the foothills zone, particularly south of Pueblo, Colorado (upper), and smooth sumac, a common shrub species found on open sites in the upper foothills and lower montane zones (lower).

MONTANE VEGETATION ZONE

The montane vegetation zone generally occurs between 7,500 and 9,000 feet elevation, depending on slope exposure. Ponderosa pine forests, often with intermingled meadows of bunchgrasses, dominate the lower montane zone. Douglas-fir forests occupy high-elevation montane sites and cool slope positions (north and east aspects in the lower montane). At the upper edge of this zone, lodgepole pine, aspen, or spruce-fir forests are occasionally found. Groves of narrowleaf cottonwood occur along low-elevation waterways; with increasing altitude, they are gradually replaced by blue spruce forest.

The montane zone has a rich diversity of plant communities. As with other vegetation zones, all of the major montane conifer species can function in either a seral or climax capacity. Figures 7-15 describe and illustrate plant communities and vegetation conditions of the foothills zone.

Ponderosa Pine Plant Communities

Ponderosa pine is characteristic of low-elevation sites with moderately deep soils, low to moderate slope gradients, and high-energy aspects (slopes receiving abundant amounts of solar radiation). This conifer is the climax tree species over much of the lower portion of the montane zone, and it is successional to more shade-tolerant conifers on many upper-montane sites.

Low-elevation ponderosa pine communities commonly have an herbaceous undergrowth with Arizona fescue, mountain muhly, blue grama, little bluestem, sun sedge, and fringed sage present in varying proportions. Geraniums (Parry and Fremont), flexile milkvetch, western yarrow, showy crazyweed, asters, and lanceleaf bluebells are frequent undergrowth forbs. Bearberry, wax currant, cliff Jamesia, true mountain-mahogany, mountain snowberry, and Parry rabbitbrush are common undergrowth shrubs. Shrubby cinquefoil is occasionally plentiful on lower-montane sites when they have been overgrazed or experienced significant soil erosion.

Stands with an open ponderosa pine overstory and a fescue-muhly undergrowth are late-seral or sub-climax plant communities. Continued plant succession on these areas will eventually result in a denser pine overstory and an increase in shade-tolerant undergrowth plants, especially shrubs or sub-shrubs such as bearberry and common juniper.

The ponderosa pine/bunchgrass communities provide valuable livestock and wildlife forage when maintained in an open (mid-seral) condition. Historically, one of the ecosystem functions of periodic wildfire was to maintain an open tree canopy; application of prescribed fire and mechanical thinning can effectively restore a similar condition for managed stands.

These climax or sub-climax ponderosa pine communities (e.g., the ponderosa pine/Arizona fescue, ponderosa pine-juniper/blue grama, and ponderosa pine/mountain muhly plant associations) have no early-seral tree species available for management. Therefore, large clearcuts or fire-caused openings will support an extremely persistent seral stage of grasses, forbs, and shrubs. Conifer forest will eventually replace these nonforest stages, but hundreds of years may pass first!

Old-growth ponderosa pine/bunchgrass stands tend to be uneven-aged with a groupy or clumpy structure. This condition is a result of wildfire patterns, previous selective timber harvest, or episodes of sporadic or intermittent natural regeneration. Tree regeneration is sporadic because optimal seedbed, seed supply, and germination conditions seldom coincide (Cooper 1960, White 1985).

On these dry, bunchgrass-dominated areas, some type of site preparation treatment will usually be necessary to obtain natural regeneration following a shelterwood seed cut or group selection entry. Tree seedling establishment should precede bunchgrass invasion if regeneration is to be successful (Fisher 1980, Larson and Schubert 1969, Pearson 1942, Rietveld 1975).

The ponderosa pine series includes much of the nonproductive forest land on the Pike and San Isabel National Forests. For example, many ponderosa pine/bunchgrass communities have low timber productivity and a savanna-like appearance. Although these low-productivity areas will never supply sustainable amounts of commercial timber volume, they are extremely valuable for livestock grazing and wildlife habitat.

Douglas-fir Plant Communities

Many stands in the upper montane zone have a ponderosa pine overstory and a Douglas-fir or white fir understory. A long period of effective fire suppression has allowed the shade-tolerant Douglas-fir to get established under the shade-intolerant ponderosa pine. The magnitude of this successional progression is demonstrated by comparing the last two forest inventories for the Pike and San Isabel National Forests – Douglas-fir ranked third of the five major forest types in 1958; by 1980, its ranking had improved to first!

Mixed stands of ponderosa pine and Douglas-fir are probably more desirable than a pure stand of either species, since a mixture provides some assurance of perpetuating a forest physiognomy. After all, it is very unlikely that mountain pine beetle and western spruce budworm outbreaks would decimate both tree species simultaneously.

Douglas-fir has more ecological amplitude than any other tree species of the Pike and San Isabel National Forests, forming ecotones with foothills (pinyon-juniper), other montane (ponderosa pine), subalpine (spruce-fir), and nonforest plant communities. This characteristic has silvicultural implications because all species with considerable amplitude, regardless of lifeform (tree, shrub, or herb), tend to have a broad genetic base, which provides considerable potential for genetic improvement.

It is believed that tree improvement efforts with Douglas-fir in the southern Rocky Mountains could yield impressive results in terms of increased growth or insect and disease resistance.

Even though Douglas-fir is normally an upper montane species, it occasionally occurs on xeric sites where ponderosa pine would be expected to dominate. At Kerr Gulch (BLM-administered lands located south of Howard and southeast of Salida) and at certain other areas in or near the Pike and San Isabel National Forests, Douglas-fir is the first commercial tree species encountered above pure pinyon-juniper associations (and this situation provides another example of Douglas-fir's wide ecological amplitude).

Douglas-fir's affinity for steep, north-facing slopes often results in 'butt sweep' or 'pistol butts' as soil creep tips trees away from a vertical orientation. Since conifers are geotropic, they will try to regain a vertical orientation as quickly as possible, and this response is what causes a sweep or pistol butt to form. Quaking aspen has misshapen boles too, but the cause is generally from snow bend or rotational slumping more often than from soil creep.

Shrubs are dominant in the undergrowth of most Douglas-fir forests. Highly productive sites often feature mountain ninebark, mountain snowberry, cliff Jamesia, Rocky Mountain maple, or myrtle pachistima in the undergrowth plant union. Sites of intermediate productivity may have creeping mahonia or russet buffaloberry as common shrubs, although some examples of the Douglas-fir/creeping mahonia plant association are reasonably productive.

Douglas-fir stands with undergrowths dominated by common juniper, true mountain-mahogany, bearberry, or Gambel oak tend to be some of our less productive sites, although exceptions do occur. For instance, white fir-Douglas-fir/Gambel oak plant communities at the base of the Sangre de Cristo Mountains are highly productive.

Graminoids are obviously present in Douglas-fir undergrowths, but they are generally subordinate to shrubs or sub-shrubs in most stands. This relationship is not unexpected because much of the Douglas-fir forest type is dense (especially pure stands), and shrubs tend to be more shade tolerant than graminoids.

Limber pine, ponderosa pine, quaking aspen, and lodgepole pine are common early- or mid-seral tree species on Douglas-fir habitat types. As might be expected, lodgepole pine's growth on these upper montane sites tends to be much poorer than when it is established on a subalpine zone habitat type.

White Fir Plant Communities

White fir, which occurs in eleven of the Pike and San Isabel National Forests' fourteen counties, is most common south of the Arkansas River. It is the climax tree species in a narrow transition zone above Douglas-fir and below subalpine fir.

Douglas-fir is so common in the white fir zone that we usually refer to the resulting mixture as the white fir-Douglas-fir forest cover type. However, it is important to remember that white fir is considered to be the major (dominant) climax species in these mixed stands because it is more shade-tolerant than Douglas-fir.

White fir and Douglas-fir are both shade tolerant (white fir more so), and they will regenerate concurrently if adequate seed sources are available. Following initial establishment of a mixed stand, wildfire, substrate variability (soils and parent materials), and insects or diseases will have the most influence on subsequent stand development.

Western spruce budworm, for example, has an obvious feeding preference for white fir, so a budworm outbreak in mixed stands can tip the balance toward Douglas-fir (although budworm feeds on both species, it does not prefer Douglas-fir as much as white fir).

Productivity data indicates that white fir has the best growth rate of any tree species on the Pike and San Isabel National Forests. Diameter growth of five to ten rings per radial inch is not uncommon, and height growth is reasonable when western spruce budworm has not seriously damaged the upper crown and terminal leader.

Even though much of white fir's impressive fiber accretion is lost to stem decay, decay-free individuals can be grown when stem damage is avoided during stand tending operations. When considering a fairly short management horizon (60-80 years), white fir can probably produce more cubic feet of wood fiber per acre than any other native tree species of the southern Front Range.

Early- or mid-seral tree and shrub species on white fir sites include quaking aspen, Gambel oak, ponderosa pine, and New Mexico locust. Douglas-fir is not included in this list because it functions as a minor climax or co-climax species for most of the white fir zone.

White fir occasionally functions as a mid-seral tree species in the lower subalpine zone on subalpine fir or corkbark fir habitat types. For example, mixtures of white and corkbark firs occur at several locations in the Spanish Peaks above 11,000 feet. In many of these stands, Armillaria root disease is killing the mid-seral white fir much more frequently than the climax corkbark fir. However, white fir is also susceptible to this fungal pathogen on sites where it is the climax tree species.

New Mexico locust is an early-seral shrub species on white fir sites in the Spanish Peaks. This aggressive tall shrub frequently forms thickets between riparian zones and upland forests. It commonly occurs with Gambel oak or mountain snowberry in a plant union featuring deciduous shrubs. Gambel oak tends to maintain dominance following fire (on the white fir-Douglas-fir/Gambel oak habitat type, for example), but New Mexico locust is often present and it may function as a surprisingly effective competitor on some forest sites.

Limber Pine Plant Communities

Rocky ridges and outcrop areas in the montane zone frequently support limber pine stands. In these situations, the limber pine plant communities can be considered to represent an edaphic climax type. Limber pine can also function as a mid- or late-seral species on dry, lower-montane sites where either Douglas-fir or ponderosa pine is the indicated climax dominant (these are plant associations with bearberry, common juniper, Arizona fescue, or sparse undergrowths, for example).

The lower-montane limber pine seral stages can be very persistent; limber pine might be present in these stands for several hundred years. Limber pine also occurs on subalpine sites, but is not as common there as bristlecone pine.

Limber pine plays an interesting role on Pikes Peak massif. Pikes Peak occurs in a rain shadow area by virtue of its considerable offset from the main axis of the Continental Divide. The rain shadow effect and associated aridity has resulted in the virtual absence of lodgepole pine on Pikes Peak.

Quaking aspen occurs as an early-seral tree species on Pikes Peak, but ecological niches that would normally be occupied by lodgepole pine are now supporting limber pine. Several large limber pine stands to the west of Halfway Picnic Ground (Pikes Peak Ranger District) originated following one or more of the severe wildfires that covered much of Pikes Peak between 1850 and 1900.[5]

It is difficult to decide whether the limber pine stands on Pikes Peak will eventually be replaced by Engelmann spruce or Douglas-fir. Both species occur sporadically as regeneration, but so little seed source remained after the fires that forest succession has proceeded very slowly since then.

Special Habitats of the Montane Vegetation Zone

Blue spruce is distinctive because it is the only conifer of the Pike and San Isabel National Forests that occurs primarily in a riparian setting. Occasionally, but not often, blue spruce is found on upland sites that seem to be far removed from the nearest riparian environment.

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[5] W.J. Gardner. 1905. Report: the problem of reforestation in the Pikes Peak Forest Reserve. Unpublished report by the Bureau of Forestry (later the United States Forest Service), including black and white photographs of denuded slopes on Pikes Peak. 70 p.

To the west of Lake George, blue spruce occurs as a fringe type on sub-irrigated, toe-slope areas where subsurface water is concentrated at the juncture between level valley-bottom areas and steeper mountain slopes. Blue spruce also occurs as a scattered component in some ponderosa pine stands on the Pikes Peak Ranger District (especially in the vicinity of Manitou Park). It's my impression that these blue spruce stands are not climax plant communities because the spruce generally occupies swales or moist microsites, rather than typical upland conditions.

The southwestern United States has several areas where blue spruce occurs on upland sites and has formed stable, self-replacing plant communities. The mixture of ponderosa pine and blue spruce on the Kaibab Plateau is an example of this situation (this is the blue spruce/Kentucky bluegrass habitat type, which also happens to be a common montane riparian association of the Pike and San Isabel National Forests).

I doubt that the ponderosa pine-blue spruce mixtures north of Woodland Park are similar to those described above for the southwestern United States, although detailed ecological studies could indicate otherwise.

Narrowleaf cottonwood and peachleaf willow remain as common riparian species in the montane zone, but have now been joined by water birch, thinleaf alder, red-osier dogwood, blue spruce, quaking aspen, fleshy hawthorn, and several shrubby willows. It is interesting that riparian tree and shrub species are overwhelmingly deciduous, especially in the foothills and lower montane zones.

Grasslands of the upper montane zone are usually moister than those of the lower montane (see ponderosa pine narrative). These parks occur where soils tend to be finer textured, deeper, and less well-drained than adjacent forest areas. Trees cannot get established in the grasslands because of competition from herbaceous communities, low temperatures associated with cold air drainage, frost heaving, poor soil aeration for portions of the growing season, and any number of other factors (some of which are well understood; some not).

Most upper-montane and subalpine parks contained extensive stands of fescue when in a pristine (climax) condition. In the northern and central Rocky Mountains, Idaho fescue was most common; for the Pike and San Isabel National Forests and other areas of the southern Rockies, Thurber fescue was predominant. As these mountain parks were disturbed, the climax fescue grassland was invaded by a plethora of forb and shrub species (western yarrow, fleabanes, geraniums, shrubby cinquefoil, agoseris, etc.).

Arizona fescue continues to be a strong component of upper-montane grasslands in association with Thurber fescue (this is the Thurber fescue-Arizona fescue plant association).

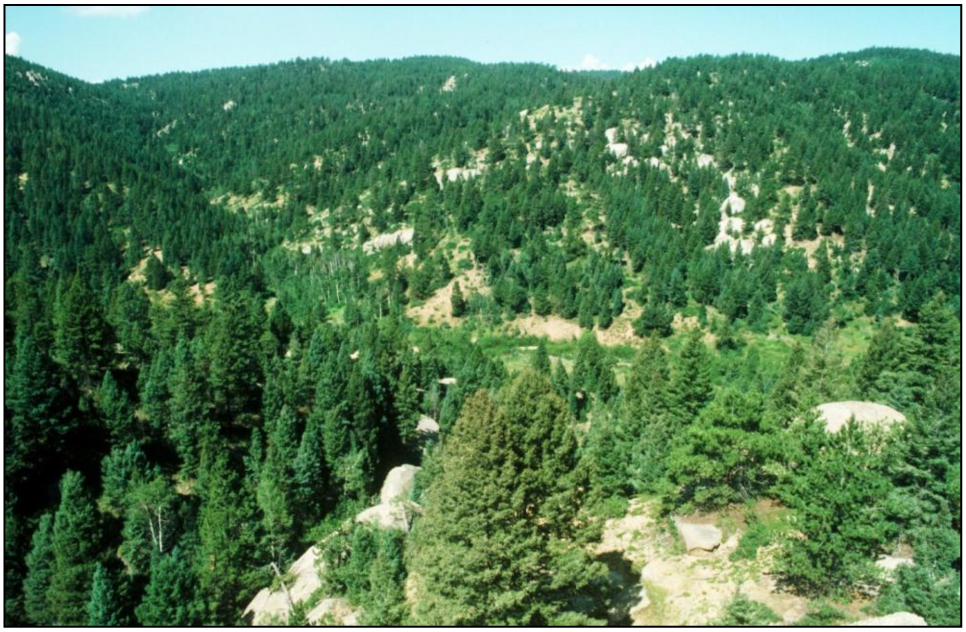

Figure 7–Typical view of the montane zone along the Front Range in the Jackson Creek area of the Rampart Range (South Platte Ranger District). In this view, the open areas tend to be caused by outcrops of the primary geologic parent material – Pikes Peak granite. Note the presence of moister grassland-low shrubland communities and a small quaking aspen clone along the creek's floodplain (middleground, center). In the outer mountain ranges of the Front Range (i.e., those ranges farther removed from the Continental Divide and closer to the eastern plains), including the Rampart Range and Tarryall Mountains, the shallow, infertile, coarse-textured soils derived from Pikes Peak granite tend to have an important influence on forest composition and structure.

Figure 8–Open, parklike stand of ponderosa pine on level topography on the Pikes Peak Ranger District, showing a dense herbaceous undergrowth composition and a sparse cohort of large-diameter trees (above); and a multi-cohort stand of ponderosa pine on the South Platte Ranger District exhibiting more tree-size diversity than the parklike stand (below).

Figure 9–Aftermath of a stand-replacing wildfire on a dry site of the lower montane zone near Lake George, Colorado (South Park Ranger District), showing total tree-kill and an absence of litter or duff to protect the soil surface except from needle drop immediately after the fire (above). The lower image does not depict Arlington National Cemetery, as might be suggested by the white markers. It shows the same area as above after tree planting has occurred, where shade cards were used to compensate for the lack of overstory shade. Note the response of fringed sage in the post-planting image, along with seeded grasses, western yarrow, and pioneer plants such as blite goosefoot.





Figure 10–Five ‘watch out’ plants for the montane vegetation zone. Forest stands in the lower montane zone are often growing on very dry sites where forest management activities must be conducted carefully to ensure that forest cover will be perpetuated through time. Five plants that function as effective indicators of dry-site conditions are shown here: blue grama (upper left); ring muhly (upper right); mountain ball cactus (middle left); plains pricklypear (middle right); and small soapweed or yucca (lower right, with poison ivy growing at its base).

Figure 11–Management options for ponderosa pine forests of the montane vegetation zone. Dry pine sites featuring an undergrowth of bunchgrasses such as Arizona fescue and mountain muhly are typically managed so some amount of overstory cover is always maintained through time, often by implementing the commercial thinning or individual-tree selection cutting methods (above; fuelwood thinning on the South Park Ranger District). Moister sites such as ponderosa pine/Gambel oak communities (below; San Carlos Ranger District) allow more silvicultural flexibility, including small group selection openings such as the one shown here containing a mix of oak sprouts and ponderosa pine seedlings.

Figure 12–Two dry-site plant communities of the montane vegetation zone. The ponderosa pine/true mountain-mahogany (PIPO/CEMO) plant community is very dry, and it features an open cohort of ponderosa pine trees and a relatively dense shrub stratum dominated by true mountain-mahogany (above; Pikes Peak Ranger District). The Douglas-fir/cliff Jamesia (PSME/JAAM) plant community is found almost exclusively on lower to mid montane sites with abundant rock outcrops, primarily because cliff Jamesia prefers this sort of rocky habitat (lower).

Figure 13–Two examples of montane vegetation zone environments. The upper image shows a broad-scale vegetation mosaic for a dry montane landscape, showing grassland, aspen forest, and mixed conifer stands dominated by ponderosa pine and Douglas-fir. The lower image portrays a fine-scale montane community featuring dry grassland in the middleground portion, and limber and ponderosa pine seedlings, a pole-sized blue spruce, and mountain big sage in the foreground view.

Figure 14–The upper montane zone often features rich tree-species diversity, as illustrated by this moist montane environment on non-granitic soils of the San Carlos Ranger District (upper). Not all of the ponderosa pine communities of the montane zone have a shrub-dominated undergrowth – the lower image shows the herbaceous undergrowth typically associated with the ponderosa pine/sun sedge (PIPO/CAHE) plant community, a mesic biophysical environment typically found on gentle terrain.

Figure 15–Western spruce budworm is an important defoliating insect causing substantial impacts in montane forests dominated by Douglas-fir or white fir. The left image shows three Douglas-firs affected by spruce budworm defoliation on a Rampart Range site (South Platte Ranger District) – note how the center tree is apparently expressing some genetic resistance to budworm defoliation. New Mexico locust (right) is a tall shrub or small tree commonly found on mid- to upper montane sites (generally white fir habitat types) in the Spanish Peaks portion of the San Carlos Ranger District.

SUBALPINE VEGETATION ZONE

The subalpine vegetation zone generally occurs between 9,000 and 11,500 feet elevation, depending on slope exposure. Douglas-fir, lodgepole pine, or quaking aspen forests dominate the lower portion, while spruce-fir stands occur at high altitudes and on cool, shaded slopes. This zone contains the most productive sites of the Pike and San Isabel National Forests.

The subalpine zone has relatively plentiful and predictable precipitation, so temperature, slope position (exposure), and soil characteristics tend to have more influence on plant distribution patterns than slope direction (aspect), which tends to function as a controlling factor for the montane zone. In fact, north-facing and south-facing subalpine slopes often support similar plant communities, particularly when considering the overstory tree species composition. Figures 19-28 describe and illustrate plant communities and vegetation conditions of the foothills zone.

Quaking Aspen and Lodgepole Pine Plant Communities

These species are discussed together because their distribution patterns are interrelated. Lodgepole pine and quaking aspen have equivalent ecological amplitude, and can usually occupy similar niches as our dominant early-seral species. They have an interesting competitive pattern along a latitudinal gradient from north to south on the Pike and San Isabel National Forests.

For the northern portion of the Pike and San Isabel National Forests (Leadville, South Platte, and northern South Park Ranger Districts), lodgepole pine is competitively superior and dominates most sites where it and quaking aspen have shared potential habitat. In this area, quaking aspen tends to occur in fringe areas at the periphery of their common habitat.

Intermediate latitudes on the Pike and San Isabel National Forests (Salida, Pikes Peak, and southern South Park Districts) have a more equal division between the two species, although lodgepole pine still has a slight edge. Upon reaching the San Carlos Ranger District, lodgepole pine has a greatly diminished distribution and quaking aspen is overwhelmingly dominant. In fact, lodgepole pine reaches its southernmost station in the Rocky Mountains on the San Carlos Ranger District (in the Spanish Peaks mountain range).

In Colorado, lodgepole pine is considered to be the climax tree species under some circumstances, especially on granitic soils (Moir 1969). While it is possible that the Pike and San Isabel National Forests have some climax lodgepole pine in the upper montane zone, I have yet to see a stand where I truly believed that this species would dominate the long-term climax tree composition. Even the lodgepole pine growing on decomposed Pikes Peak granites in the Rampart

Range area of the South Platte and Pikes Peak Ranger Districts appears to be a persistent, mid-seral plant community on a Douglas-fir habitat type.

Some studies suggest that cone habit (closed versus open) might provide a clue about lodgepole pine's successional status (Marr 1967). If correct, then recognizing areas on the Pike and San Isabel National Forests where lodgepole pine is primarily nonserotinous could help identify climax stands. This identification process is important because management strategies will certainly vary for successional versus climax lodgepole pine communities.

The Pike and San Isabel National Forests have persistent lodgepole pine stands, and perhaps a few of them function as a climax plant community. The persistent stands are generally found on areas of gentle terrain, such as valley bottoms, benches, or broad alluvial terraces. Since these landforms tend to collect cold air moving downslope, particularly during cool seasons (autumn, winter, spring) and at night, and because lodgepole pine has very high frost tolerance, it is likely that many of the persistent lodgepole pine stands occupy frost pocket areas.

A good example of this situation is provided by lodgepole pine stands in the Lodgepole Flats area of the Leadville Ranger District – they occur on gentle terrain, and appear to be persistent examples of the lodgepole pine/russet buffaloberry plant community type located adjacent to nonforest (sage) communities.

In the subalpine zone, quaking aspen is primarily an early-seral tree species. On some sites in the upper montane, however, aspen forms uneven-aged stands when it occurs as a fringe type between conifer stands and grassland parks. Occasionally after fire, aspen will invade the grasslands, but it then functions as an early-seral species and quickly succumbs to fungal attacks, intertree competition, and other mortality-inducing factors.

Often, quaking aspen in these grassland seres is no larger than a shrub. 'Shrubby' aspen also occurs at upper timberline in the Spanish Peaks, where it is successional on sites that previously supported mixed stands of Engelmann spruce and bristlecone pine.

The presence of uneven-aged aspen stands in the Rocky Mountains has long been recognized, but factors controlling their establishment and perpetuation are not fully known (Betters and Woods 1981). A multi-storied stand structure consisting entirely of quaking aspen clearly demonstrates that aspen is successfully replacing itself on these sites, and this situation seems to offer support for the possibility that aspen can function as a climax species.

Throughout the western United States where aspen and conifers occur together, the vegetation pattern often features a mosaic of forest and small meadows (fig. 16). The succession in these areas is generally from meadow to forest, but destruction of a forest stand by wildfire frequently sets the area back to meadow (Daniel et al. 1979, Schimpf et al. 1980).

Figure 16–Large aspen stand in the East Williams Creek area, Wet Mountains, San Carlos Ranger District, Pike and San Isabel National Forests. For many areas in Utah, Colorado, and northwestern Wyoming, quaking aspen occurs in large stands, although an individual stand commonly contains more than one clone. In the Blue Mountains, aspen tends to occur as very small stands covering a fraction of an acre.

"Where aspens occur on the margins of a stand, they advance into the meadow by means of root suckers, provide shade, reduce gopher concentrations, and give a favorable seedbed and growing conditions for establishment of the conifers" (Daniel et al. 1979).

"Tolerance is a forestry term for expressing the relative capacity of a tree to compete under low light and high root competition. Tolerant trees reproduce and form understories beneath canopies of less tolerant trees or even beneath their own shade. Intolerant trees reproduce successfully in the open or where the canopy is greatly broken. A knowledge of tolerance and its implications for competitiveness and growth is fundamental to good silviculture and should support every management decision" (Daniel et al. 1979).[6]

When considering how the major tree species of the Pike and San Isabel National Forests have been rated according to tolerance, we find that subalpine fir is classed as very tolerant; Engelmann spruce and white fir are tolerant; Doug-

[6] Note that Daniel et al. (1979) use tolerance in a broader sense than just shade tolerance. At least partly in response to root-trenching studies described by Zon (1907), tolerance has historically been used to refer to a species' ability to tolerate both shade and root competition.

las-fir and blue spruce are intermediate; ponderosa pine, lodgepole pine, and limber pine are intolerant; and bristlecone pine and quaking aspen are very intolerant (Daniel et al. 1979, table 13-2).

These tolerance ratings suggest that aspen plant communities owe their existence to two ecosystem processes:

1. Stand-initiating disturbance events such as wildfire, which function as "destruction" agents and initiate a new plant succession beginning with meadow; and
2. Forest stand dynamics, where the life history traits of individual tree species control how post-disturbance succession evolves through time.

As a very intolerant species, aspen only regenerates and develops acceptably in open environments. Aspen's suckering ability allows it to quickly produce a prolific amount of reproduction ideally suited for exploiting post-disturbance conditions. But to thrive, aspen suckers require an environment relatively free of competition from other tree species, particularly from species that are more tolerant than aspen.

Since all of the conifers except bristlecone pine are more tolerant than aspen, they represent a significant competition risk to the long-term health and vigor of aspen communities. This means that as plant succession progresses, aspen's initial competitive advantage wanes because shading, soil acidity and chemistry, and other site conditions gradually evolve in favor of the tolerant conifers.

Although human society has decided to suppress the primary disturbance process responsible for maintaining aspen plant communities (stand-initiating wildfire), society could choose to mitigate one of the effects of this decision by using timber harvest or prescribed fire to regenerate successionally advanced aspen stands.

Using management activities to regenerate successionally advanced aspen stands would acknowledge that for the evergreen-dominated forests of western North America, aspen provides more value for aesthetics and biological diversity than would be expected from its relatively minor abundance on the landscape. Some ecologists have suggested that aspen functions as a keystone species, providing essential ecosystem services for a very large suite of plants and animals (DeByle and Winokur 1985).

Subalpine Fir and Corkbark Fir Plant Communities

Corkbark fir is a variety of subalpine fir occurring primarily on the San Carlos Ranger District. It is also present on the Salida Ranger District's portion of the Sangre de Cristo Mountains. Several other areas of the Pike and San Isabel National Forests have high-elevation fir with characteristics intermediate between these two phenotypes.

Studies comparing the two varieties of subalpine fir are lacking, but we should assume that they have similar silvics and life history traits (shade tolerance, phenology, etc.).

Corkbark fir appears to be another species having its northernmost Front Range distribution on the Pike and San Isabel National Forests (also see similar discussions for pinyon-juniper, Gambel oak, and white fir).

Subalpine fir's distribution is more sensitive to moisture than its common subalpine associate – Engelmann spruce. This sensitivity is evident after examining its habitat range in two "rain shadow" areas of the Pike and San Isabel National Forests: the Spanish Peaks and Pikes Peak.

The Spanish Peaks are a volcanic uplift located east of the Culebra Range, which is a portion of the main axis of the Sangre de Cristo Mountains in southern Colorado (fig. 3). Corkbark fir is relatively abundant in the mesic Culebras but is restricted to sheltered sites of the lower subalpine zone in the Spanish Peaks. Engelmann spruce and bristlecone pine are dominant on about two-thirds of the Spanish Peaks subalpine habitat because they are able to compete successfully under xeric conditions.

At Pikes Peak, subalpine fir is virtually absent; Engelmann spruce, quaking aspen, bristlecone pine, and limber pine are the predominant tree species of the subalpine zone. The dry climatic conditions of this prominent Front Range landmark have resulted in the virtual absence of both lodgepole pine and subalpine fir (also see a similar discussion in the limber pine plant communities section).

In the northern Rocky Mountains of Wyoming and Montana, subalpine fir occurs throughout the subalpine zone and is usually present at upper timberline. In the southern Rockies, however, subalpine fir is confined to the lower half of the spruce-fir zone, and it is seldom encountered at timberline.

The central Rocky Mountains are a transitional region where subalpine fir becomes more important as a timberline species with increasing latitude. For example, subalpine fir is coequal with Engelmann spruce in Rocky Mountain National Park, and it is obviously dominant at timberline in southern Wyoming in the Snowy Range.

There are several possible explanations for subalpine fir's restricted elevational range in the southern Rockies. A likely reason is that subalpine forests of southern Colorado and the southwestern United States have more variation in moisture conditions and slope exposure than spruce-fir forests farther north.

Studies in Utah, for example, have identified instances where precipitation amounts for mid-slope areas were as great as, or even greater, than those for upper-slope sites (Schimpf et al. 1980). If a similar pattern exists for the Pike and San Isabel National Forests, then maximum precipitation and soil moisture could very well occur in lower subalpine areas having protected exposures (e.g., moist side slopes, moist flats, and bottoms or draws).

Another possible explanation for the geographical distribution of subalpine fir might involve genetic variation within its population. Spruce-fir stands of the central and northern Rocky Mountains contain typical subalpine fir (*Abies lasiocarpa* var. *lasiocarpa*), whereas those of the southern Rockies have corkbark fir (*Abies lasiocarpa* var. *arizonica*). Perhaps genetic differentiation into two varieties resulted in corkbark fir being relegated to lower, more sheltered sites within the subalpine zone (but to my knowledge, this hypothesis has not been tested).

Extensive areas of the lower subalpine zone contain stands in the subalpine fir/grouse whortleberry habitat type. This plant community is one of the most widespread habitat types of the western United States. The undergrowth plant union is dominated by low shrubs of the whortleberry genus; grouse whortleberry is common at high elevations (including timberline and above), while Rocky Mountain whortleberry is predominant on many mid- to low-elevation subalpine sites.

Forbs and grasses are relatively uncommon in the subalpine fir/grouse whortleberry habitat type, although moist areas (bogs, seeps, springs) have diverse plant unions featuring arrowleaf groundsel, bunchberry, elkslip marshmarigold, Woods strawberry, brook saxifrage, or heartleaf bittercress. Woods rose, heartleaf arnica, asters, sedges, and bluejoint reedgrass are also occasionally present on subalpine fir/grouse whortleberry sites.

Quaking aspen is a common, early-seral species of the lower subalpine zone, although lodgepole pine generally assumes this role at higher elevations and at northern latitudes of the Pike and San Isabel National Forests. Plant associations in the subalpine fir series form ecotones with Engelmann spruce associations at higher elevations, and with white fir-Douglas-fir associations at lower elevations.

Engelmann Spruce Plant Communities

In the southern Rocky Mountains, plant associations with Engelmann spruce as the dominant tree species occupy the highest forested sites of the subalpine zone. Ecotones occur with krummholz or alpine tundra at higher elevations, and with subalpine fir habitat types at lower elevations. The elevational distribution of Engelmann spruce and subalpine fir in a subalpine zone stand is shown in figure 17.

It has been suggested that plant associations containing Engelmann spruce to the exclusion of subalpine fir might represent the dry range of timberline conditions. Although they may be drier than adjacent subalpine fir sites, these Engelmann spruce stands receive ample snowfall and have high potential for manipulation to increase water yields. Small patch clearcuts ranging from 3 to 5 tree heights in diameter have been most effective at redistributing the winter snowpack for increased water yield (fig. 18; EPA 1980).

In addition to being cold and somewhat dry, forested sites of the upper subalpine zone often have shallow, rocky soils and exposed slope positions (ridge summits, upper side slopes, etc.). This combination of abiotic factors typically results in low site productivity, although protected cirque basins and other sheltered landforms can have relatively high productivity.

Mature Engelmann spruce plant associations can be regenerated using cutting methods from the even-aged or uneven-aged silvicultural systems, but the choice of a cutting method will generally depend on the presence or absence of early-seral tree species and their expected response to active management.

Old-growth stands can be virtually pure Engelmann spruce, in which case the early-seral species expected to occupy a large clearcut would consist of perennial grasses and sedges, redberried elder, bearberry honeysuckle, mountain bluebells, and other non-tree plant species.

In some respects, Engelmann spruce habitats of the upper subalpine are analogous to climax ponderosa pine communities because both occur at a treeline (upper and lower, respectively), so each must be carefully managed to ensure tree regeneration and to sustain a forested (tree-dominated) physiognomy.

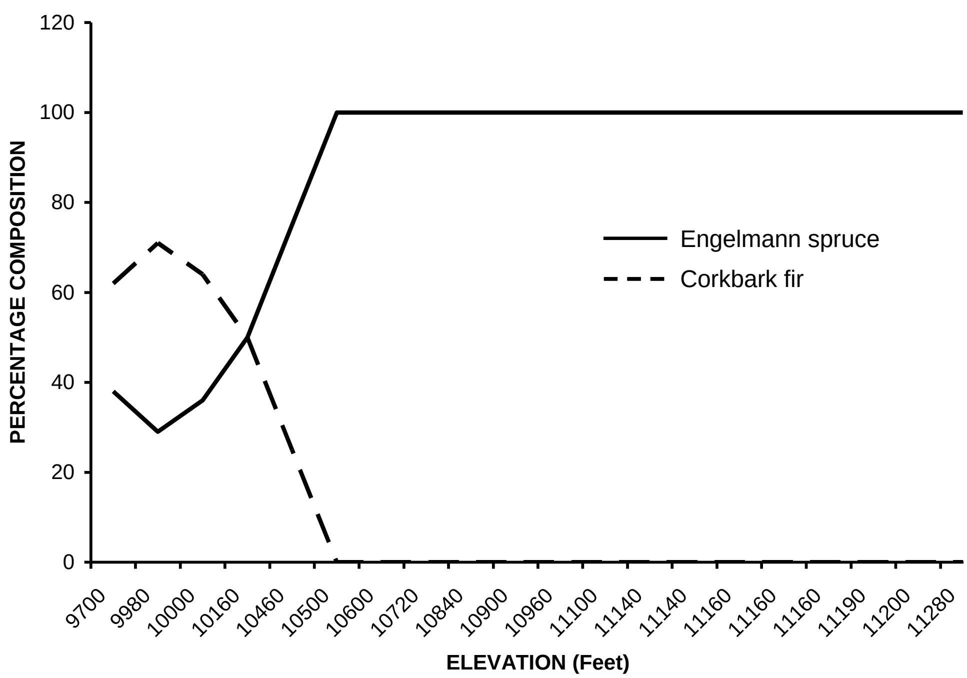

Figure 17–Percentage composition of Engelmann spruce and subalpine fir by elevation; stand 103512-019 (RIS location-site), San Carlos Ranger District, Pike and San Isabel National Forests (sample basis: 20 sample points, 169 variable-plot tally trees). Source: Prescription for silvicultural certification prepared by David C. Powell in January 1981.

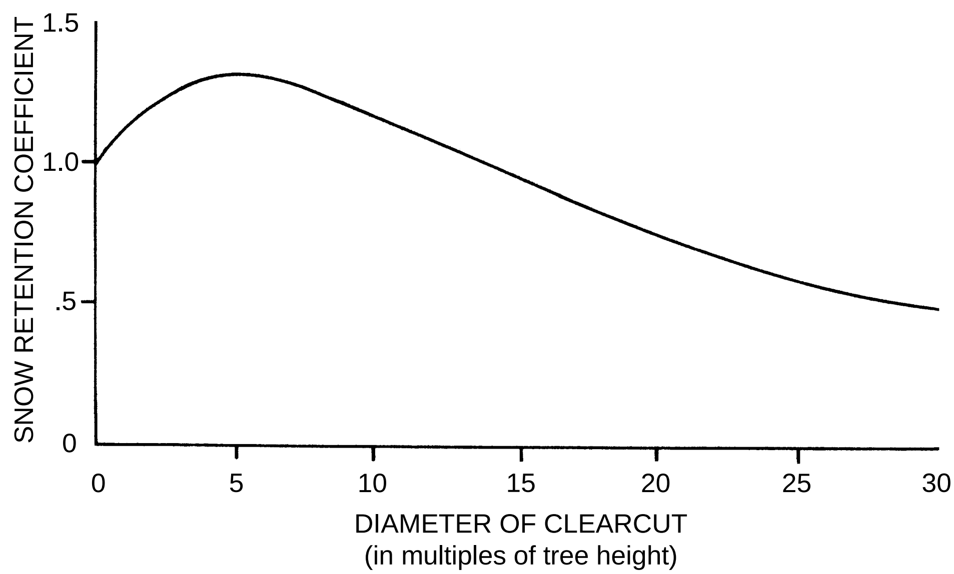

Figure 18–For spruce-fir forests of the subalpine zone, snow retention varies with opening size (U.S. EPA 1980). Note that the units-of-measure for the "diameter of clearcut" axis is a number (multiples) of tree height.

Quaking aspen and lodgepole pine are common early-seral species on Engelmann spruce habitat types, although bristlecone pine is probably the most common early- or mid-seral associate at high elevations of the subalpine zone.

Engelmann spruce plant associations include a relatively wide range of moisture and substrate variability. Dry spruce stands often occur within the Engelmann spruce/moss plant association. These stands have sparse undergrowths with shrubs and herbs uncommon, and mosses or lichens dominant. Sidebells pyrola is often present in conjunction with mountain muhly, Northwest cinquefoil, and fleabanes.

High-elevation areas where Engelmann spruce stands and moist subalpine meadows are intermixed often occur on the Engelmann spruce/gooseberry currant habitat type. These sites are very distinctive because the gooseberry currant usually grows in dense patches at the base of individual trees or spruce clumps. This plant community has been referred to as a "ribbon forest" because it occurs as a ribbon of spruce and gooseberry currant wending through moist meadows of sheep and Thurber fescues, sedges, Bigelow ligularia, and other herbs or shrubs.

A common plant association of moist depressions is the elkslip marshmarigold phase of the Engelmann spruce/Rocky Mountain whortleberry plant association. The marshmarigold phase is encountered in level areas where the water table is near the ground surface, or in situations where a subsurface impediment precludes complete infiltration of snowmelt runoff. Elkslip marshmarigold is clearly dominant on these sites, but brook saxifrage, heartleaf bittercress, cornhusk lily, sedges, and grasses also occur. In the Wet and Sangre de Cristo Mountains, bunchberry often occurs in the undergrowth plant union of this phase.

Engelmann spruce/whortleberry plant associations (Engelmann spruce/grouse whortleberry; Engelmann spruce/Rocky Mountain whortleberry) have undergrowth plant unions that change slowly following disturbance, seldom resulting in post-treatment communities that compete aggressively with tree seedlings.

Spruce stands with a high coverage of forbs, grasses, rushes, and sedges are the other extreme, since many potential invasion species (Ross sedge and other sedges; Wheeler bluegrass and Kentucky bluegrass; and bluejoint reedgrass, for example) could be present before treatment, and they are certainly capable of capturing and holding the site should timber harvest, wildfire, or another disturbance process provide them with an opportunity to do so.

Bristlecone Pine Plant Communities

Bristlecone pine is dominant in some areas of the Spanish Peaks and Pikes Peak, primarily because of their dryness and the frequency of widespread wildfire. Some stands in the Spanish Peaks have an intermingling of ponderosa pine, bristlecone pine, and Gambel oak. In these interesting situations, ponderosa pine and Gambel oak have apparently moved up the slope, whereas bristlecone pine has moved down in elevation.

This species distribution pattern occurs because the Culebra Range intercepts much of the precipitation arriving from the west or southwest before it can reach the Spanish Peaks. Since bristlecone pine and ponderosa pine are successful at occupying xeric ecological niches, they have become dominant over more of the Spanish Peaks than would normally be expected at these elevations.

Bristlecone pine is also common on Pikes Peak, where it appears to be as plentiful on the north slope of the massif as the south. While its dominance there can be attributed to the dryness of Pikes Peak massif, many of the stands are persistent seral stages being slowly invaded by Engelmann spruce. These seral stages arose following the episodic wildfires covering much of the massif between 1850 and 1900 (see footnote #5).

Bristlecone pine is renowned for its longevity. The famous stands in the White Mountains of eastern California contain Great Basin bristlecone pine (*Pinus aristata* var. *longaeva*) that are 4,600 years old. Stands in the Pike and San Isabel National Forests contain Rocky Mountain bristlecone pine (*Pinus aristata* var. *aristata*), which is not quite as long-lived as the Great Basin variety but still capable of impressive age (2,000 years).

Bristlecone pine stands usually have sparse undergrowths. Sites with shallow, rocky soils and exposed slope positions are particularly depauperate, with graminoids (purple pinegrass, sedges, spike trisetum, sheep fescue, etc.) being more common than shrubs or forbs. The bristlecone pine/purple pinegrass plant association is an example of a plant community that would commonly be found on these depauperate sites.

Mesic sites can support a dense overstory – bristlecone pine stands having 200 square feet or more of basal area per acre were sampled in the 1980 forest inventory for the Pike and San Isabel National Forests.

The bristlecone pine stands with high stocking levels have a more diverse undergrowth than bristlecone pine/purple pinegrass associations: western yarrow, Whipple penstemon, heartleaf arnica, wormleaf stonecrop, and other forbs are not uncommon in the plant unions. Many of these mesic stands are examples of the bristlecone pine/whiproot clover plant association.

Special Habitats of the Subalpine Zone

Timberline and upper treeline[7] occur at progressively higher elevations as one moves south on the Pike and San Isabel National Forests. In addition, the occurrence of dwarfed spruce or subalpine fir in a zone of krummholz (also called elfinwood) becomes less frequent at southern latitudes. At Mt. Evans on the South Platte Ranger District (Guannela Pass specifically) and at several other mesic locations, the transition between forest and alpine tundra is separated by krummholz; in the Wet Mountains and other southern-latitude mountain ranges, krummholz is uncommon and an abrupt boundary usually occurs between forest and tundra.

As mentioned previously, Engelmann spruce is the predominant krummholz species in the southern Rockies, although dwarfed bristlecone pine is occasionally present at southern latitudes and on xeric sites (Pikes Peak, etc.). Undergrowth plants in krummholz formations often include a strong alpine component such as whiproot clover, golden avens, and dwarf clover, in addition to many plants normally associated with upper subalpine forest.

Krummholz can adopt two forms: a prostrate form on sites with heavy snow accumulations (cushion krummholz), and a semi-erect form with one-sided foliage on sites experiencing high wind velocities (flagged krummholz). Flagged krummholz is constantly blasted by granular snow particles as abrasive as sand; their action removes foliage and branches on the windward sides and leaves a small band of foliage and branches on the leeward side.

[7] Some sources consider these to be synonymous terms. For this discussion, timberline is defined as the area where stands of normally formed trees end. Upper treeline is the area where trees of any shape or size no longer occur. Upper treeline and timberline are often separated by a narrow zone of krummholz.

A thick area of callus-like tissue usually forms on the windward side of the tree bole (opposite the flagged foliage) and helps to prevent permanent snow-blast damage from occurring there. Flagged krummholz also forms a prostrate component in the protected area beneath the snowline, so these elfin trees have photosynthetic capabilities in both vertical and horizontal dimensions.

A common progression is to move from timberline (full-sized trees) and krummholz (dwarf trees) in the upper subalpine zone to several different types of treeless plant communities in the alpine zone. The lower alpine often has meadows where soils have accumulated, featuring communities dominated by grasses and sedges but also containing showy plants such as Rydbergia, alpine primrose, paintbrushes, bistorts, golden avens, and alpine wallflower.

The upper alpine zone generally has shallow soils and much exposed rock in environments referred to as fellfields (fell is celtic for rock). Fellfields feature cushion plants that are highly adapted to occupy crevices between the rocks, such as yellow stonecrop, alpine forget-me-not, moss campion, alpine phlox, whiproot clover, and alpine sandwort (Zwinger and Willard 1972, Marinos and Marinos 1981).

The majority of the subalpine zone has small, poorly developed riparian plant communities. They adjoin small streams and rivulets, many of which won't merge to form large streams or small rivers until reaching the montane zone. Most subalpine streams occupy narrow, V-shaped ravines with steep side slopes, rocky stream beds, and steep channel gradients.

Growing near subalpine streams are Parry primrose, heartleaf bittercress, brook saxifrage, elkslip marshmarigold, mountain bluebells, several willow species, and numerous other hydric plants.

Tall willow shrublands (carrs) with an undergrowth of grasslike plants usually occur where alluvium is present and the water table is at or near the soil surface for part of the year. These carrs are dominated by numerous shrubby willows (often half a dozen or more species) and they have sedges, rushes, and bluejoint reedgrass in their undergrowths.

Willow carrs are extremely important as an integral component of our subalpine drainage system. They typically occur at headwater areas of most subalpine streams and are usually the first areas to collect and transport snowmelt runoff.

Subalpine parklands are present because edaphic or topographic factors have prevented a conifer community from developing. Subalpine parks are fairly common on south-facing exposures just under a ridgeline (for ridges not reaching the alpine zone). These areas are topographically situated in such a way that winds remove their winter snowpack, and late spring or summer drought often occurs.

Low-elevation subalpine parks generally have a strong shrub component, whereas herbs often predominate in higher parks. This life-form gradient continues upslope into the alpine zone, where shrubs are very infrequent and perennial members of the grass (Poaceae), sedge (Cyperaceae), saxifrage (Saxifragaceae), mustard (Brassicaceae), and buckwheat (Polygonaceae) families are most common. The alpine shrubs that do occur are usually from the rose (Rosaceae), willow (Salicaceae), and heath (Ericaceae) families.

Thurber fescue continues to be a dominant species in subalpine grasslands, where it is commonly associated with Idaho fescue, sheep fescue, numerous forbs, and other graminoids. Sedges, tufted hairgrass, and Kentucky bluegrass are common species in snow accumulation zones or on other moist sites such as the tufted hairgrass/alpine timothy plant association, for example.

Subalpine parks occasionally have a strong forb component in the ecotone area near moist spruce-fir stands. Elkslip marshmarigold, rosecrown stonecrop, and several species of late-blooming gentians (Rainier pleated gentian and Arctic gentian, in particular) commonly occur in these ecotones such as areas assigned to the tufted hairgrass/elkslip marshmarigold plant association.

Figure 19–Quaking aspen and lodgepole pine are the most common early-seral tree species of the upper montane and lower subalpine zones. Aspen forest occupies a wide range of environmental conditions; the upper image shows a common upland aspen type on the South Park Ranger District (the quaking aspen/ spreading thermopsis community type). Lodgepole pine tends to occur as an early-seral, pioneer species following disturbance, but it is also found as a stable or persistent (climax?) plant community in the upper montane zone. The lower image shows a good example of the lodgepole pine/Rocky Mountain whortleberry (PICO/VAMY) habitat type on the Pikes Peak Ranger District.

Figure 20–Using forest management practices to perpetuate quaking aspen forest. As montane or subalpine aspen stands become successionally advanced, what often began as a relatively pure aspen community gradually evolves to a mixed composition with a high proportion of conifers (above). Silvicultural practices can be used to regenerate these mixed stands, but the treatment must be severe enough to tip the successional balance back toward quaking aspen, our most shade-intolerant tree species (below, showing an aspen regeneration clearcut located near Gold Camp road, Pikes Peak Ranger District).

Figure 21–Much of the upper subalpine vegetation zone features old-forest stands with an overstory having relatively simple species composition (typically dominated by Engelmann spruce but with varying amounts of subalpine fir, above), and an undergrowth plant union commonly containing one or more species of *Vaccinium* (such as *V. scoparium* or *V. myrtillus*). The undergrowth of these spruce/*Vaccinium* plant communities often includes Rocky Mountain whortleberry, heartleaf arnica, bunchberry, forest fleabane, and scattered individuals of fireweed or Richardson geranium (below).

Figure 22–Perhaps the most common mesic community at lower elevations of the subalpine zone is the subalpine fir/forest fleabane (ABLA/EREX) habitat type (above). This plant community features a relatively rich assortment of forbs, and although shrubs or sub-shrubs are found, they are less abundant than for the spruce/*Vaccinium* types. Moist riparian environments of the lower subalpine are represented by communities such as the subalpine fir-Engelmann spruce/arrowleaf groundsel-Barbey larkspur (ABLA-PIEN/SETR-DEBA) plant community (below). Columbia monkshood, common cowparsnip, and other tall forbs are also common in these riparian plant communities.

Figure 23–Not all Engelmann spruce forest occurs on moist sites. On Pikes Peak massif and other rain-shadow areas of the Pike and San Isabel National Forests, the dry-site Engelmann spruce/moss plant association is often found (above). These stands feature a depauperate undergrowth, where occasionally the only plant species are sidebells pyrola and a few rattlesnake plantain. They must be managed carefully to ensure that a forest physiognomy is sustained through time (below, on the Pikes Peak Ranger District, showing the persistent evidence of an old thinning entry).

Figure 24–A common stand-replacing disturbance process of subalpine spruce-fir forest is wildfire, which tends to recur with long return intervals. Fire can follow spruce beetle outbreaks if they function as a predisposing event by creating copious amounts of dead, dry fuel. The image above shows an upper subalpine fire several years after its occurrence (Maes Creek fire, which burned in May-June 1978, near the south end of the Wet Mountains, San Carlos Ranger District). In the upper subalpine zone, tree regeneration often seems to be more abundant in the presence of dead trees, and when this site-modifying protection is absent, recruitment of new trees can be prolonged for decades to centuries (below, Mt. Zion area, Leadville Ranger District).

Figure 25–Regeneration situations of the subalpine zone. When regeneration cutting is followed quickly by tree planting, and when planted seedlings are protected from frost heaving and solarization damage, then plantations can be successfully established (above). But when regeneration is delayed for more than just a few years, or when it is not successful at all (in the near term), then rhizomatous sedges and dense herbaceous plants can successfully delay tree recruitment, such as the sedge mats and fireweed patches shown here (below; both images are from the San Carlos Ranger District).

Figure 26–Bristlecone pine or limber pine plant communities occur on dry sites of the montane and subalpine zones. Although bristlecone pine often occurs in open stands on exposed slope positions, it is also found in closed stands such as the one shown here (above; South Park Ranger District). Limber pine also occurs in the subalpine zone, but it is probably more common on rocky ridges and outcrop areas in the upper montane zone (below; Indian Creek drainage, San Carlos Ranger District). On the south slope of Pikes Peak, limber pine occurs in dense, pure stands originating after widespread forest fires in the mid to late 1800s.

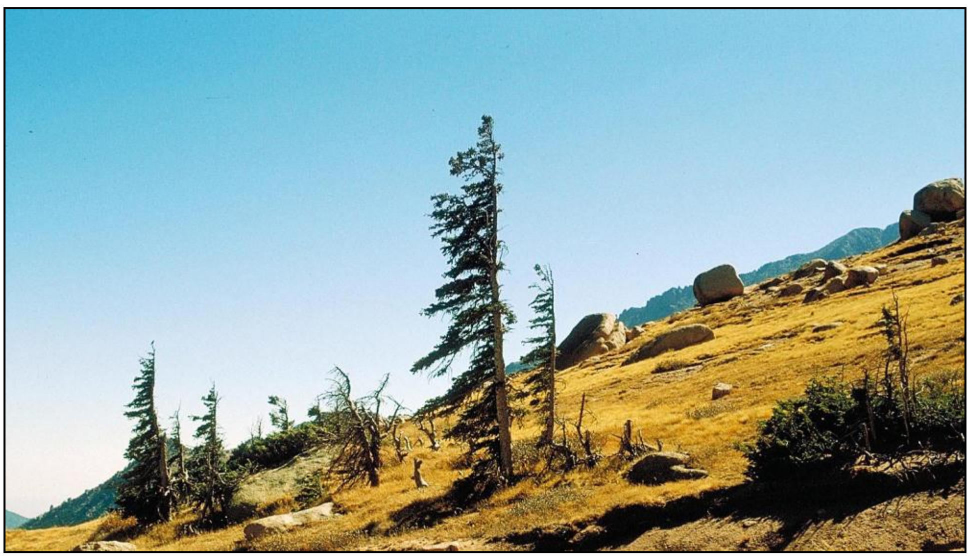

Figure 27–A special habitat called krummholz is found in the upper subalpine zone near treeline. Flagged krummholz adopts an upright form with foliage concentrated along the leeward side away from the prevailing wind direction (below; Engelmann spruce krummholz on Pikes Peak, Pikes Peak Ranger District). Cushion krummholz has a low-growing, rounded growth form because it is protected from abrasive and desiccating winds by existing beneath the winter snowpack (above; bristlecone pine krummholz in the Michigan Creek drainage, South Park Ranger District).

Figure 28–Wetland environments of the subalpine zone. Small bogs or seeps frequently occur in spruce forest, often dominated by elkslip marshmarigold (above); large bogs often feature narrowleaf cottonsedge (center); occasionally, spruce swamps are found (below; Salida Ranger District).

Figure 29–Two common plants of the alpine vegetation zone. Beyond upper treeline is the alpine zone, where krummholz and the subalpine zone give way to a treeless expanse of broken rock or shallow soils. In open rocky areas, a common species is alpine thistle (top); note how little soil this site supports, and the resulting lack of other vegetation. Alpine sites with soil development support a complex assemblage of 'cushion' species such as Rydbergia, alpine primrose, paintbrushes, bistorts, golden avens, and alpine wallflower (such areas support 'belly botany' where plants are best observed from a prone position). The bottom image shows a diminutive form of Colorado columbine (with golden avens in the background), indicating that some plants with wide ecological amplitude are found from montane sites clear up to the alpine zone.

STATUS OF VEGETATION CLASSIFICATION EFFORTS

A recent report describing plant associations of Region Two (USDA Forest Service 1981) is obviously incomplete with regard to the distribution of subalpine plant associations for the Pike and San Isabel National Forests (and for other national forests in the southern portion of Region 2 as well). It shows two spruce-fir associations occurring on the San Isabel National Forest, and two Engelmann spruce associations occurring on the Pike National Forest.

More comprehensive habitat-type coverage should be provided by a Rocky Mountain Forest and Range Experiment Station study of the forested habitat types in the southern part of the Region (this study area includes the San Carlos Ranger District).

Until the habitat typing study is complete, it is incumbent on us to use the information provided by this plant identification field guide (e.g., Powell 1982) and similar references to improve the Region's plant association classification. After all, the Region's plant association report includes a sufficient number and variety of plant associations to adequately characterize habitat types of the Pike and San Isabel National Forests; what it lacks is correct distribution information (i.e., presence or absence) for the associations occurring on this Forest.

The Current Situation

The habitat type study described above (first three paragraphs of this section) was eventually finished, and results were presented in a general technical report issued by the Rocky Mountain Station (DeVelice et al. 1986). During the study, 48 plots were established on the San Carlos Ranger District and 2 on the Salida Ranger District (both Salida plots were located in the Sangre de Cristo Mountains near the San Carlos Ranger District boundary).

Publication of the DeVelice et al. (1986) report was the culmination of potential vegetation classification work initiated by Region Two in the late 1970s. The first product of this effort was a draft report by Terwilliger and others (1979), followed quickly by another draft report (USDA Forest Service 1981). The Rocky Mountain Research Station study was initiated during the same timeframe in which these two draft reports were released.

Concurrent with the Rocky Mountain Research Station efforts, the Regional Ecologist (Barry Johnston) was publishing successive editions of a plant association guide for the Rocky Mountain Region (see Johnston 1987 as an example). In some instances, the information presented in Johnston's guide was based on plot data he collected; in others, the plant association information reported for a particular national forest was based on a literature review process.

By compiling a roster of plant associations known to occur in the Rocky Mountain Region, Johnston's concept was that distribution information for these associations would be continuously refined as stand examinations and rangeland condition surveys were completed. This approach was based on the assumption that most of the primary plant associations of the Rocky Mountain Region had already been identified, and all that was needed is better information about their distribution within the Region.

However, subsequent classification work (such as Powell 1988) suggests that the existing roster of plant associations, as compiled by Johnston (1987), probably did not describe the full range of plant associations occurring on the Pike and San Isabel National Forests. As this white paper was being prepared more than 20 years later, it seems that the same situation exists today – the full range of plant associations on the Pike and San Isabel National Forests has still not been adequately characterized (personal communication, Floyd Freeman, Salida Ranger District).

APPENDIX 1: SPECIES LIST

Common name	Scientific name	Scientific Name (PLANTS)
agoseris	Agoseris spp.	
alpine forget-me-not	Eritrichium aretioides	Eritrichium nanum
alpine phlox	Phlox condensata	
alpine primrose	Primula angustifolia	
alpine sandwort	Minuartia obtusiloba	
alpine thistle	Cirsium scopulorum	
alpine timothy	Phleum commutatum	Phleum alpinum
alpine wallflower	Erysimum nivale	Erysimum capitatum purshii
antelope bitterbrush	Purshia tridentata	
Arctic gentian	Gentiana algida	
Arizona fescue	Festuca arizonica	
armillaria root disease	Armillaria ostoyae	
arrowleaf groundsel	Senecio triangularis	
asters	Aster spp.	Symphyotrichum spp.
Barbey larkspur	Delphinium barbeyi	
bearberry	Arctostaphylos uva-ursi	
bearberry honeysuckle	Lonicera involucrata	
Bigelow ligularia	Ligularia bigelovii	Senecio bigelovii
bistorts	Bistorta spp.	Polygonum spp.
blite goosefoot	Chenopodium capitatum	
blue grama	Bouteloua gracilis	
blue spruce	Picea pungens	
bluejoint reedgrass	Calamagrostis canadensis	
boxelder	Acer negundo	
bristlecone pine	Pinus aristata	
brook saxifrage	Saxifraga odontoloma	
bunchberry	Chamaepericlymenum canadense	Cornus canadensis
cholla	Opuntia imbricata	Cylindropuntia imbricata
cliff Jamesia	Jamesia americana	
Columbia monkshood	Aconitum columbianum	
common chokecherry	Prunus virginiana	
common cowparsnip	Heracleum sphondylium	Heracleum maximum
common juniper	Juniperus communis	
corkbark fir	Abies lasiocarpa arizonica	
cornhusk lily	Veratrum tenuipetalum	
creeping mahonia	Mahonia repens	
Douglas-fir	Pseudotsuga menziesii	
dwarf clover	Trifolium nanum	
elkslip marshmarigold	Caltha leptosepala	
Engelmann spruce	Picea engelmannii	

Common name	Scientific name	Scientific Name (PLANTS)
fireweed	Chamerion angustifolium	
fleabanes	Erigeron spp.	
fleshy hawthorn	Crataegus macracantha	Crateagus succulenta
flexile milkvetch	Astragalus flexuosus	
forest fleabane	Erigeron eximius	
Fremont geranium	Geranium caespitosum	
fringed sage	Artemisia frigida	
Gambel oak	Quercus gambelii	
geraniums	Geranium spp.	
golden avens	Acomastylis rossii	Geum rossii
gooseberry currant	Ribes montigenum	
grouse whortleberry	Vaccinium scoparium	
heartleaf arnica	Arnica cordifolia	
heartleaf bittercress	Cardamine cordifolia	
Idaho fescue	Festuca idahoensis	
Kentucky bluegrass	Poa pratensis	
lanceleaf bluebells	Mertensia lanceolata	
lanceleaf cottonwood	Populus x-acuminata	
limber pine	Pinus flexilis	
little bluestem	Schizachyrium scoparium	
lodgepole pine	Pinus contorta	
moss campion	Silene acaulis	
mountain ball cactus	Pediocactus simpsonii	
mountain big sagebrush	Artemisia tridentata vaseyana	
mountain bluebells	Mertensia ciliata	
mountain muhly	Muhlenbergia montana	
mountain ninebark	Physocarpus monogynus	
mountain pine beetle	Dendroctonus ponderosae	
mountain snowberry	Symphoricarpos oreophilus	
myrtle pachistima	Pachistima myrsinites	Paxistima myrsinites
narrowleaf cottonsedge	Eriophorum polystachion	Eriophorum angustifolium
narrowleaf cottonwood	Populus angustifolia	
New Mexico locust	Robinia neomexicana	
Northwest cinquefoil	Potentilla gracilis	
oneseed juniper	Juniperus monosperma	
paintbrushes	Castilleja spp.	
Parry geranium	Geranium parryi	Geranium caespitosum parryi
Parry primrose	Primula parryi	
Parry rabbitbrush	Chrysothamnus parryi	Ericameria parryi
peachleaf willow	Salix amygdaloides	
pinyon pine	Pinus edulis	

Common name	Scientific name	Scientific Name (PLANTS)
plains cottonwood	Populus deltoides	
plains pricklypear	Opuntia polyacantha	
poison ivy	Toxicodendron rydbergii	
ponderosa pine	Pinus ponderosa	
purple pinegrass	Calamagrostis purpurascens	
quaking aspen	Populus tremuloides	
Rainier pleated gentian	Gentiana calycosa	
rattlesnake plantain	Goodyera oblongifolia	
redberried elder	Sambucus racemosa	
red-osier dogwood	Swida sericea	Cornus sericea
Richardson geranium	Geranium richardsonii	
ring muhly	Muhlenbergia torreyi	
Rio Grande cottonwood	Populus acuminata	Populus deltoids wislizeni
Rocky Mountain juniper	Juniperus scopulorum	
Rocky Mountain maple	Acer glabrum	
Rocky Mountain whortleberry	Vaccinium myrtillus	
rosecrown stonecrop	Clementsia rhodantha	Rhodiola rhodantha
Ross sedge	Carex rossii	
rushes	Juncus spp.	
russet buffaloberry	Shepherdia canadensis	
Rydbergia	Hymenoxys grandiflora	Tetraneuris grandiflora
Saskatoon serviceberry	Amelanchier alnifolia	
sedges	Carex spp.	
sheep fescue	Festuca saximontana	
showy crazyweed	Oxytropis splendens	
shrubby cinquefoil	Pentaphylloides floribunda	Dasiphora fruticosa
sidebells pyrola	Orthilia secunda	
sideoats grama	Bouteloua curtipendula	
skunkbush sumac	Rhus aromatica trilobata	Rhus trilobata
small soapweed	Yucca glauca	
spike trisetum	Trisetum spicatum	
subalpine fir	Abies lasiocarpa	
sun sedge	Carex heliophila	Carex inops heliophila
thinleaf alder	Alnus tenuifolia	Alnus incana tenuifolia
Thurber fescue	Festuca thurberi	
true mountain-mahogany	Cercocarpus montanus	
tufted hairgrass	Deschampsia cespitosa	
water birch	Betula fontinalis	Betula occidentalis
wax currant	Ribes cereum	
western spruce budworm	Choristoneura occidentalis	
western yarrow	Achillea millefolium	

Common name	Scientific name	Scientific Name (PLANTS)
Wheeler bluegrass	Poa nervosa	
Whipple penstemon	Penstemon whippleanus	
whiproot clover	Trifolium dasyphyllum	
white fir	Abies concolor	
willows	Salix spp.	
Woods rose	Rosa woodsii	
woods strawberry	Fragaria vesca	
wormleaf stonecrop	Sedum lanceolatum	

Nomenclature of vascular plants follows Weber and Johnston (1979) for scientific names, and Powell (1987) for common names. All common names are shown in lower case letters except for proper names (e.g., Rocky Mountain maple, Bigelow ligularia).

Note that nomenclature for scientific plant names was revised when the U.S. Department of Agriculture adopted a national taxonomy called the PLANTS database (USDA NRCS 2008). The new PLANTS nomenclature for scientific name (if applicable) is provided in the third column.

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